Design and Performance of Implantable Inverted S Shape Antenna for Biomedical Applications

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Abstract ─ The objectives of this paper, to design a CPW fed inverted S shape antenna for biomedical applications, operates in the frequency range of 2.4-2.48GHz. In this paper to design a patch antenna and simulate with human phantom model such as skin, fat and muscle with their relative dielectric constant. The total volume of the proposed antenna is 12*14 mm2 with the thickness of 1.6mm, and this antenna is embedded in Rogers substrate (RO3010) with the dielectric value of 10.2. The inverted-S shape antenna is simulated by using CST (computer simulation technology) and the parameters are measured such as lower return loss, impedance view, VSWR, radiation pattern and gain etc. The proposed antenna is shows the better accuracy and performance compared to other antennas.

Index Terms - Inverted-S shape antenna, implantable bio-medical application, ISM band, 2.4-2.48GHz.

I. INTRODUCTION

In recent research activities in biomedical applications, an implantable antenna assures the substantial growth in patient's health and their life [1]. The implantable antennas are operate in the range of MICS (401-406MHz) and ISM band (2.45GHz)[2], it just a few example of electromagnetic field and radio frequency application. The patch antennas have compact size and low profile so it makes the necessary use of medical implant devices mostly telemetry application the patch antennas are place the important role[3]-[5]. It makes the communication between patients and doctors, so the treatment performance is so easy, the patient's need not stay in hospital for week or month. The implantable patch antenna are makes the easy communication between doctor and patient.

The method of feeding is coplanar waveguide, in this case CPW (Coplanar waveguide) feed proposed for high frequency response [6]-[8], so the accuracy of the proposed system is increased and no back radiation is occurred. The proposed system is analyzed with human tissues like skin, fat and muscle with their relative dielectric constant. In this case the length of the skin and fat is 4mm and length of the muscle is 8mm.

The proposed system is designed with CPW feed, so it response the high frequency range and to condense the back radiation of an antenna. The total volume of an antenna is very small i.e. 10*10 mm, thickness is 1mm. Then the hexagon shape bow-tie antenna is designed and analyzed with human phantom model such as skin, fat and muscle with their relative dielectric permittivity, electrical conductivity and mass density, and measures the antenna parameters [9]-[10].

In this work, an inverted-S shape CPW fed implantable antenna is designed for medical devices as a medium for biomedical applications at ISM band are designed. CPW feeding method is used to simplify the fabrication and to reduce the radiation loss. Implantable antennas are small antennas similar to classic antennas used for common wireless applications such as mobile phones [11].

II. ANTENNA DESIGN:

Geometrical view of inverted S shape antenna shown in Fig.1. The dimensions of proposed

geometry are represented in Table 1. The flow of design methodology for this proposed antenna is given below as a flowchart which is given in Fig.2.

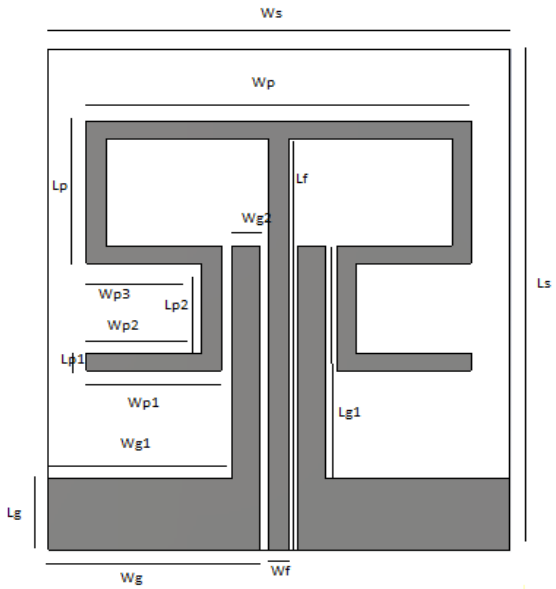

Fig 1 Antenna geometry

Table 1 Dimensions of proposed antenna

Ws	Ls	Wf	Lf	Wg	Lg	Wp	Lp	Wg1	Wg2	Lg1	Wp1	Wp2	Wp3	Lp1	Lp2
12	14	0.5	11.5	5.5	2	10	4	4.75	0.75	6.5	3.5	3	3	0.5	2.5

The proposed patch antenna is embedded in Rogers RO3010 with dielectric value of 10.2 and which is designed and analyzed with the human tissues like Skin, fat and muscle [12] with their relative dielectric properties which is tabulated in Table 2.

Table 2 Electrical properties

S.No	Tissues	Permittivity	Conductivity
1	Skin	εr = 38	σ = 1.46
2	Fat	εr = 5.28	σ = 0.10
3	Muscle	εr =52.7	σ = 1.73

The total volume of the inverted-S patch antenna is 12*14*1.6mm3. A 50ΩCPW fed line of a single conductor width is 1mm and the gap is 0.25mm. CPW feed inverted-S shape antenna designed for bio-medical applications. The simulation setup model for proposed system is shown in Fig.3.

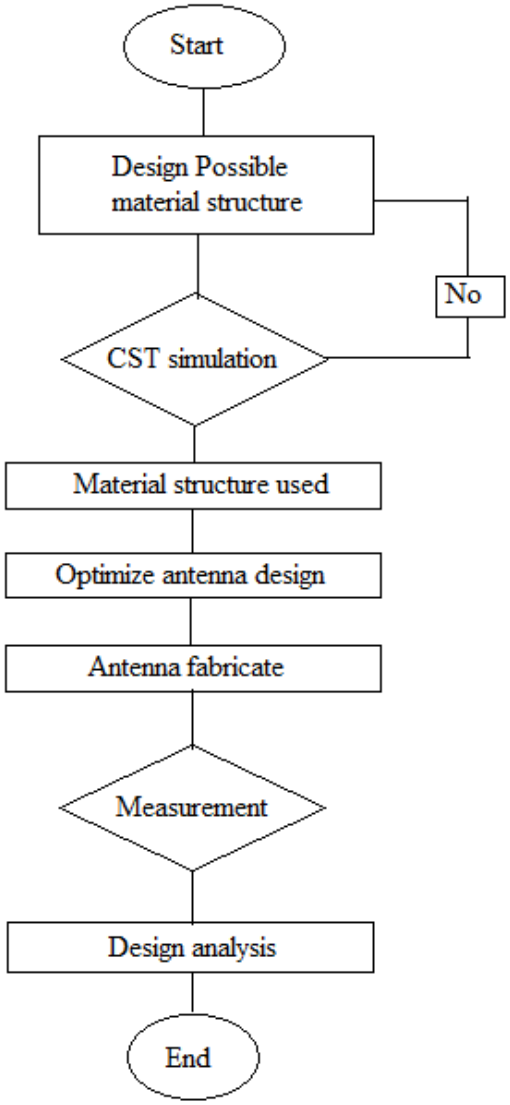

Fig.2 Design methodology

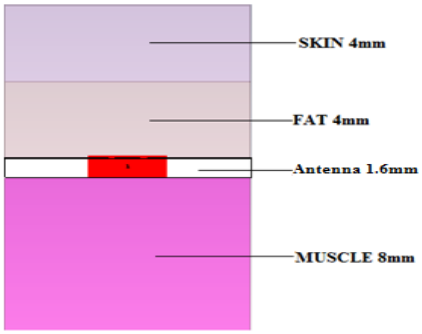

Fig.3 Simulation model setup

III. RESULTS

An implantable antenna has been designed and antenna parameters are measured and analyzed with network analyzer. The proposed system is simulated by CST (Computer simulation software). The proposed inverted-P shape patch antenna is fabricated and tested in human body fluid [Fig.4]. The ingredients of human body liquids are deionised water, sodium chloride (NACl) and sugar etc. The measured parameters are given below.

Fig.4 Photograph for Experimental Setup

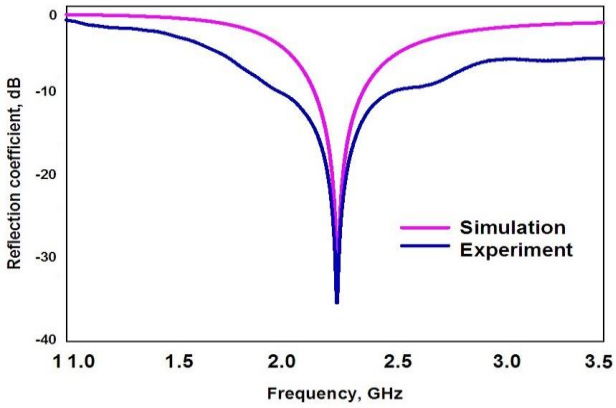

Fig.5 Return loss Vs frequency

IV. DISCUSSION

The return loss characteristic of an antenna shows a return loss at 2.45GHz. Fig.5 exhibits a return loss value of inverted-S patch is -37dB. So it dominantly affects the lower frequency. Few amounts of transmitted power are reflected back to the port so this kind of antenna is absolutely sufficient for implanted biomedical application in the range of ISM band. It shows 1:2 VSWR, so the impedance matching is perfectly matched.

The radiation pattern of proposed structure shows gain, E-field & H-field as given in Fig.6. The E field is measured based on theta (θ) value in both 90 and 180.

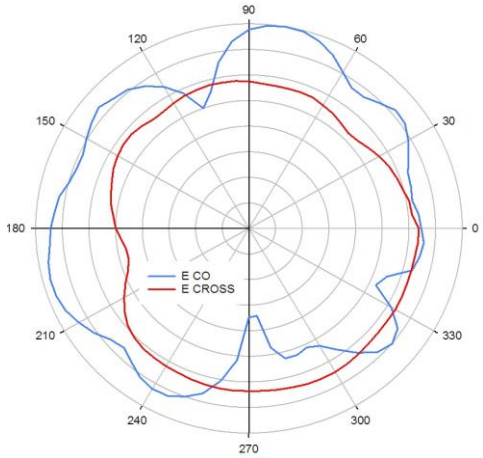

Fig.6(a) Cross polarization and co polarization of E-plane

The cross polarization and co polarization levels in E-plane is -3.08dB and -1.62dB. The total antenna efficiency is 17% in the frequency of 2.45GHz ISM band. The gain of the proposed antenna is shows -14.7dBi at the frequency range of 2.44GHz. The EM characteristics of the proposed antenna are clarified by to simulate the current distribution at 2.45 GHz as shown in Fig.7.

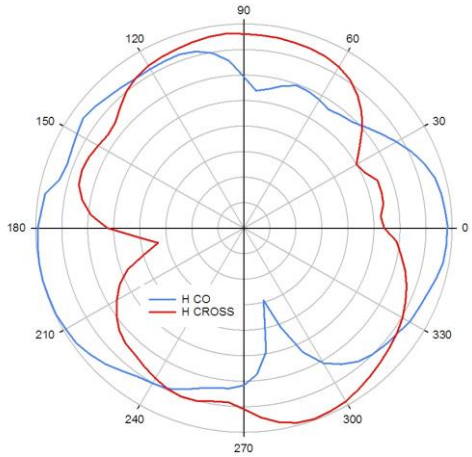

Fig.6(b) Cross polarization and co polarization of H-plane

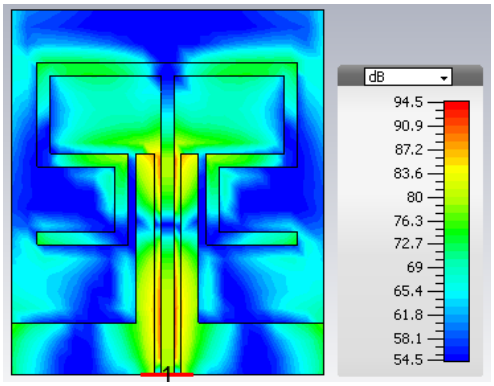

Fig.7 Current distribution

V. CONCLUSION

In this paper, to propose the inverted-S patch structure with 2.45GHz i.e. ISM band for the application of implantable bio-medical industries. The proposed system is simulated by using CST software and we measured and analyzed the antenna parameters. An inverted-S patch antenna is analyzed with human tissue model like skin, fat and muscle. The lower return loss is achieved by using high dielectric constant value of Rogers (RO3010) substrate with the thickness of 1.6mm. so we achieved very small structure i.e.12*15*1.6mm3. The measured results of proposed antenna are better compare to other implantable antennas. Hence the current antenna structure is suitable for implantable bio-medical application at ISM band.

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